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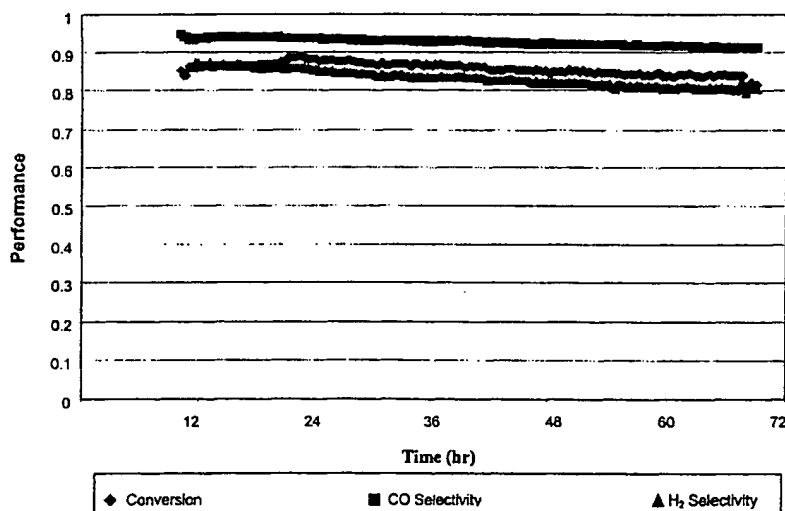
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[Continued on next page]

(54) Title: LANTHANIDE-PROMOTED RHODIUM CATALYSTS AND PROCESS FOR PRODUCING SYNTHESIS GAS



(57) Abstract: Lanthanide-promoted rhodium-containing supported catalysts that are active for catalyzing the net partial oxidation of methane to CO and H<sub>2</sub> are disclosed, along with their manner of making and high efficiency processes for producing synthesis gas employing the new catalysts. A preferred catalyst comprises highly dispersed, high surface area rhodium on a granular zirconia support with an intermediate coating of a lanthanide metal and/or oxide thereof and is thermally conditioned during catalyst preparation. In a preferred syngas production process a stream of methane-containing gas and O<sub>2</sub> is passed over a thermally conditioned, high surface area Rh/Sm/zirconia granular catalyst in a short contact time reactor to produce a mixture of carbon monoxide and hydrogen.

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 01/27450

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 C01B3/38 C01B3/40 B01J23/63		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 C01B B01J		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ, API Data		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 16737 A (SHELL CANADA LTD ;SHELL INT RESEARCH (NL)) 6 June 1996 (1996-06-06)  examples 2,4,5,7 ---	1-51, 69-81, 83,84, 102-146
X	WO 99 48805 A (CARPENTER IAN WILLIAM ;JOHNSON MATTHEY PLC (GB); HAYES JOHN WILLIA) 30 September 1999 (1999-09-30) examples 1,2 ---	1,8,20, 69
X	EP 0 640 561 A (SHELL INT RESEARCH) 1 March 1995 (1995-03-01) claims 1-13; examples 1,4 --- <div style="text-align: center;">-/--</div>	25-43, 47-51
<div style="display: flex; justify-content: space-between;"> <span><input checked="" type="checkbox"/> Further documents are listed in the continuation of box C.</span> <span><input checked="" type="checkbox"/> Patent family members are listed in annex.</span> </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search  <div style="text-align: center;">25 March 2002</div>		Date of mailing of the international search report  <div style="text-align: center;">24 07 2002</div>
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3018		Authorized officer  <div style="text-align: center;">Veefkind, V</div>

## INTERNATIONAL SEARCH REPORT

International Application No  
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 974 551 A (CHIYODA CHEM ENG CONSTRUCT CO) 26 January 2000 (2000-01-26)  example 7  ---	102, 104-107, 112-117
X	US 5 023 276 A (YARRINGTON ROBERT M ET AL) 11 June 1991 (1991-06-11) column 5 -column 7  ---	1,25,69, 102
X	EP 0 333 037 A (IGARASHI AKIRA C O KOHGAKUIN U) 20 September 1989 (1989-09-20) examples 4-7  -----	102-119

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 01/27450

## Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
  
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
  
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-51,69-84,102-146

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-51,69-84,102-146

Independent claims 1,25,69,102 and 120, and their dependent claims, relating to methods and catalysts for partial oxidation, characterized in that the catalyst contains Rh and a lanthanide.

2. Claims: 52-55,85-101

Independent claims 52,85 and 94, and their dependent claims, relating to a method and a catalyst for partial oxidation, and a catalyst preparation method, characterized in that the metal (Rh) surface area is at least 1.25 m<sup>2</sup>/ gram catalyst.

3. Claims: 56-68

Independent claim 56, relating to a method for partially oxidizing a gas mixture comprising methane and oxygen under specific conditions over a high surface area catalyst structure.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 01/27450

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Information on patent family members

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